Πως γίνεται η παρακολούθηση των ασθενών με αμφικοιλιακό βηματοδότη.

Τι είναι δυνατό στην κλινική πράξη

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CRT: An established therapy

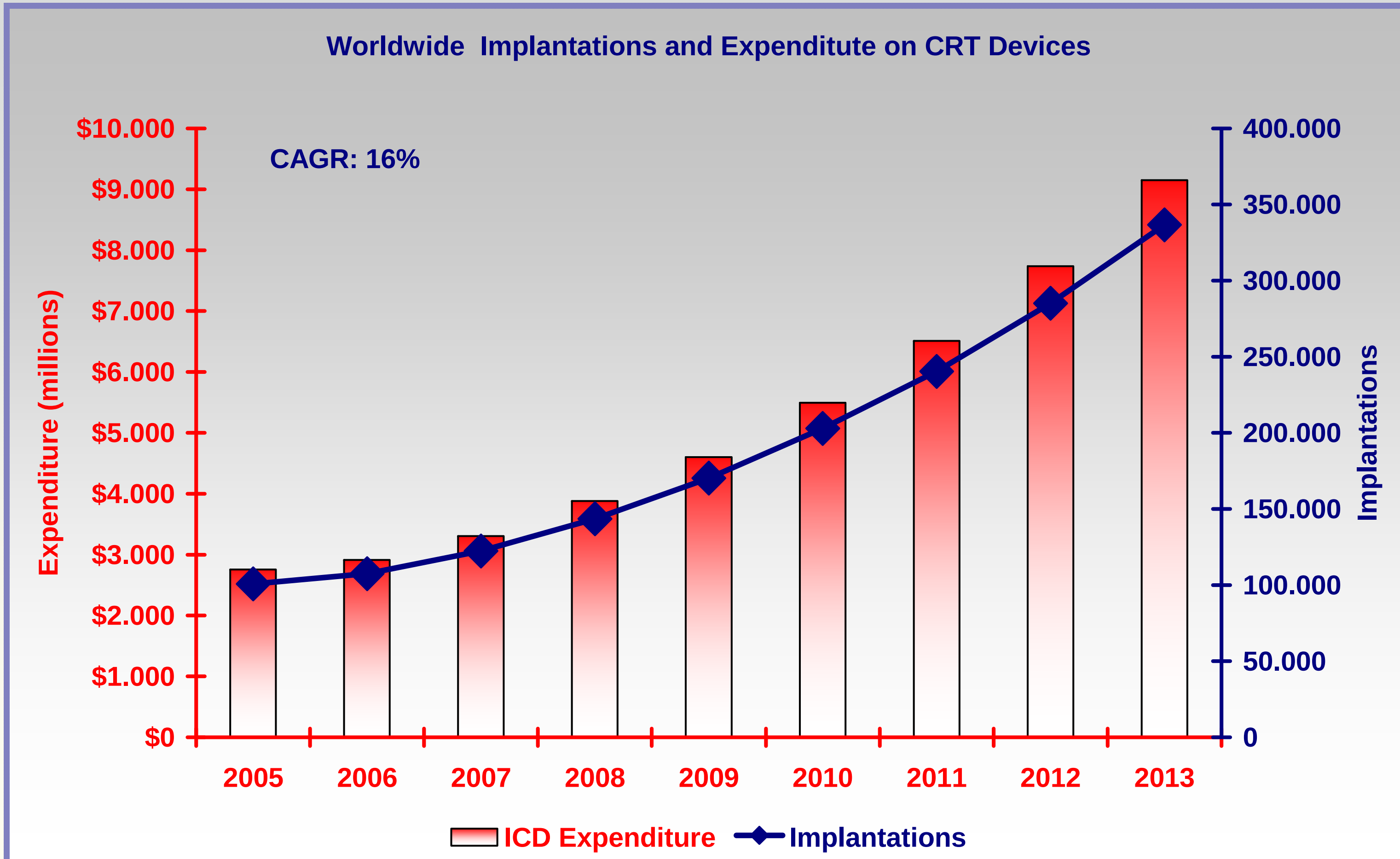
- ❑ **EF ≤ 35%**
- ❑ **QRS ≥120 ms**
- ❑ **LV dilatation**

In *NYHA III, IV* despite OPT

to reduce: symptoms
morbidity and
mortality

Vardas et al. ESC Guidelines 2007

Trend in CRT Devices Worldwide



CRT follow up

Objectives

To obtain the maximum benefit from CRT it is crucial to

- **Properly manage the patient**
- **Properly follow up the device**

CRT- specific aspects

- Candidates.
  - Pts with advanced HF
- Procedure.
  - Relatively difficult with increased complications
- Non responders.
  - 30% (clinical response),
  - 45% (echo response)

CRT patients follow up

Should be initiated soon after implantation and should focus on

- Identification-correction of procedure related complications
- Optimal device programming
- Appropriate biventricular pacing delivery
- Assessment of optimal AV and VV intervals

Schedule for follow up studies and techniques

		Immediate post implant	First month	First trimester	Every 6 months
System function					
Sensing thresholds	Pacemaker programming	●	●	●	●
Pacing thresholds	Pacemaker programming	●	●	●	●
Troubleshooting	Pacemaker programming	●	●	●	●
Rate programming	Pacemaker programming (S/T aided)	○	●	○	○
Optimum synchronization					
AV delay optimization	Echocardiography	●	○	○	○
RV-LV delay optimization	Echocardiography	●	○	○	○
Patients' response					
NYHA class	History	–	●	●	●
Functional capacity	6 minutes walk distance/CPX	–	○	○	○
LV remodeling	Echocardiography	–	○	○	○

Panos E. Vardas **Journal of Interventional Cardiac Electrophysiology 9, 183–187, 2003**

Predischarge follow up-Procedure related complications

- Coronary sinus or other epicardial vein dissection 2% - 4%
- Cardiac tamponade 0,9%
- Cardiac arrhythmias 2,8%
- Diaphragmatic stimulation
- Lead dislodgement 2% - 14%

Initial programming

- Pacing mode (VDD, DDD, DDDR, VVIR)
- Upper – lower rate
- PVR algorithm
- Pacemaker diagnostic function

Typical device follow up

- Interrogation of the pacing system
- Review of telemetry data
- Assessment of the underlying rhythm
- Atrial, left/right/biventricular pacing and sensing thresholds
- Proper programming to optimize device function and longevity

Typical devise follow up

- Delivery of 100% BiV stimulation
- Optimal programming of AV and VV intervals
- Atrial arrhythmia management
- Monitoring of ventricular arrhythmias

Heart Failure Decompensation and All-Cause Mortality in Relation to Percent BiV Pacing in Patients With HF

Is a Goal of 100% BiV Pacing Necessary?

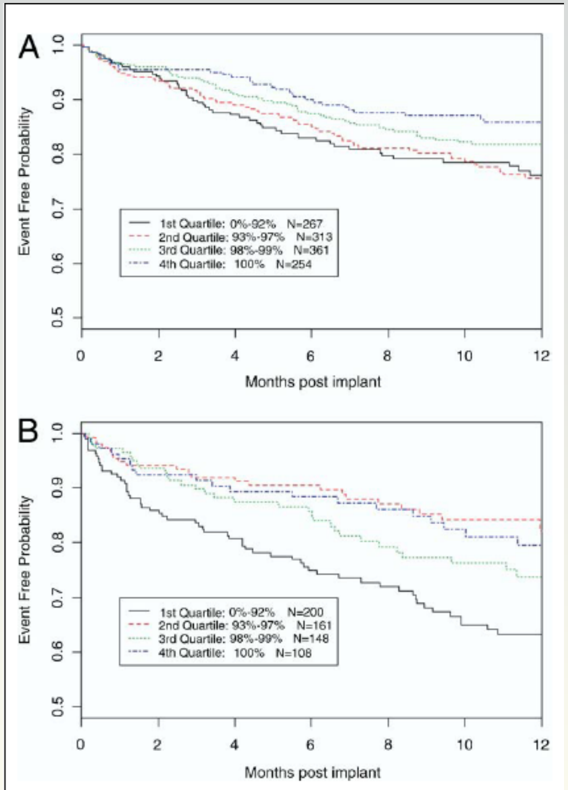


Figure 3 **Survival Free From HF Hospitalization and All-Cause Mortality in Patients With No History of Atrial Arrhythmia and Patients With History of Atrial Arrhythmia**

(A) Survival free from heart failure (HF) hospitalization and all-cause mortality in patients with no history of atrial arrhythmia. Q2 to Q4 versus Q1, HR: 0.68, $p = 0.02$; Q3 to Q4 versus Q2, HR: 0.66, $p = 0.01$; Q4 versus Q2 to Q3, HR: 0.66, $p = 0.04$. **(B)** Survival free from heart failure hospitalization and all-cause mortality in patients with a history of atrial arrhythmia. Q2 to Q4 versus Q1, HR: 0.44, $p < 0.00001$; Q2 versus Q1, HR: 0.34, $p < 0.001$. Abbreviations as in Figure 2.

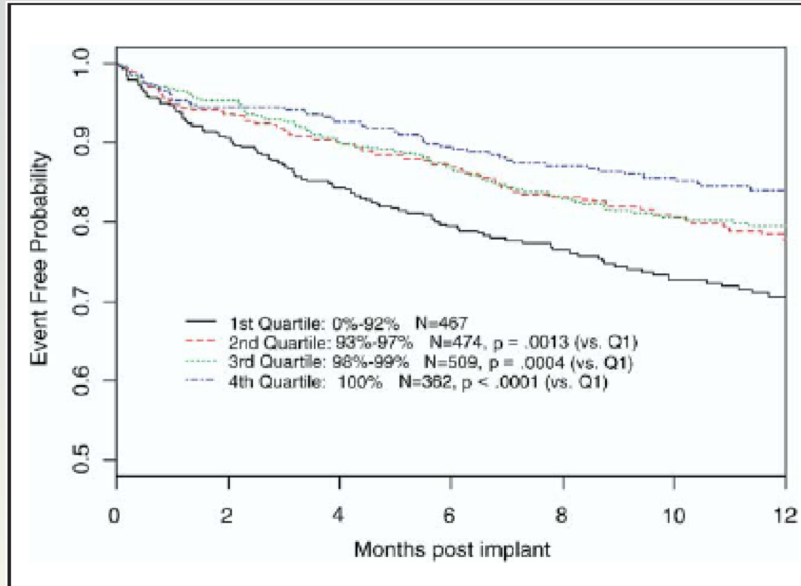


Figure 2 **Survival Free From Heart Failure Hospitalization and All-Cause Mortality in All Patients**

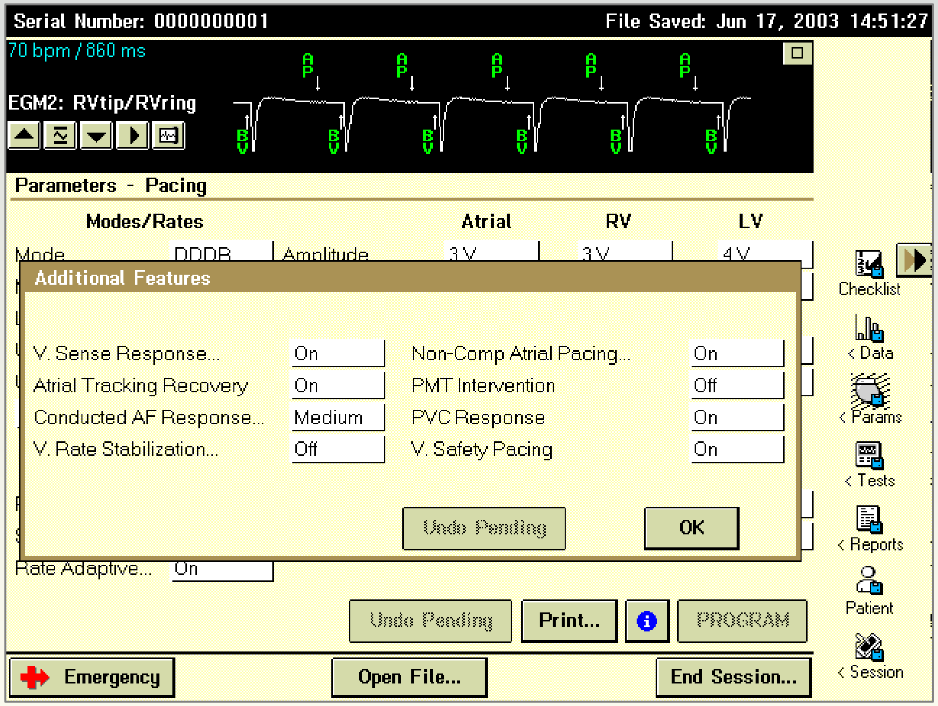
Quartile (Q)2 versus Q1, hazard ratio (HR): 0.62, $p = 0.0013$; Q3 versus Q2, HR: 0.97, $p = 0.82$; Q4 versus Q3, HR: 0.78, $p = 0.17$; Q2 to Q4 versus Q1, HR: 0.56, $p < 0.00001$.

For CRT patients in this retrospective analysis, the greatest magnitude of benefit was observed with 92% biventricular pacing.

Coplan et al JACC 2009

Maintain CRT Delivery

- **Ventricular Sense Response**
  - **In the presence of ventricular sensed events**
- **Conducted AF Response**
  - **In the presence of rapidly conducting AF**
- **Atrial Tracking Recovery**
  - **In the presence of atrial refractory sensed events**



Ventricular Sense Response

- VSR ensures V pacing in the presence of V sensing.
- Works in tracking and non tracking modes.
- When in a tracking mode DDD(R), you always want AV synchrony, so VSR only works on V events in the AV interval.
- In non tracking modes (DDI, DDIR, VVI and VVIR) the VSR can occur at any time.

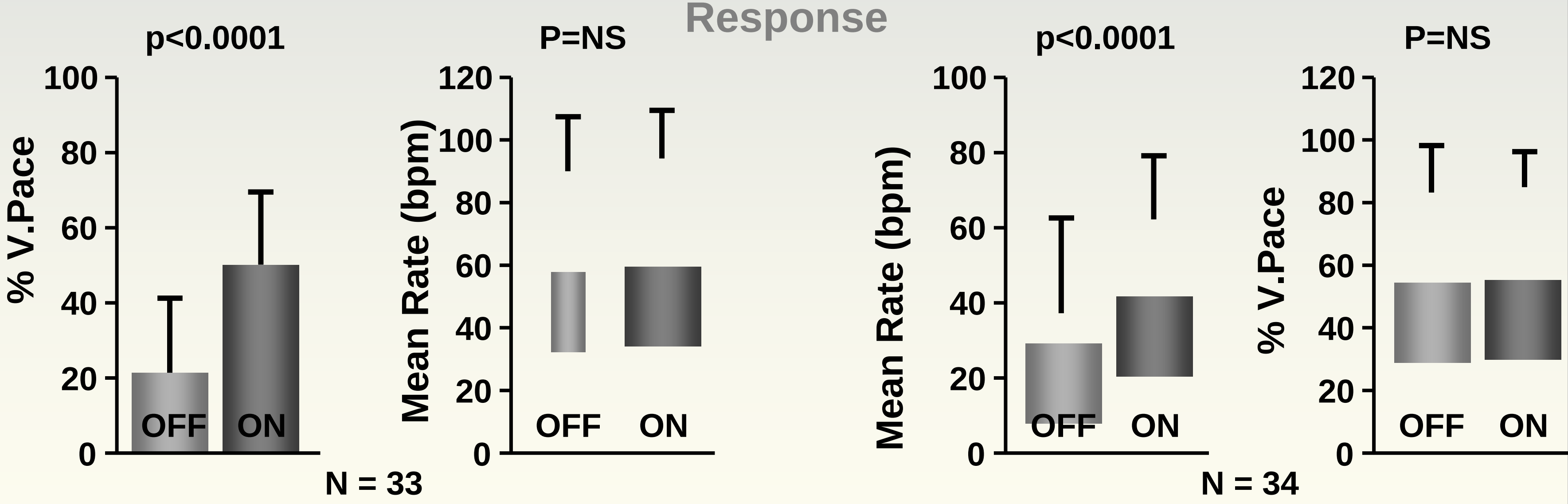
Conducted AF Response

- CAFR adjusts the ventricular pacing rate to promote CRT delivery during conducted AT/AF episodes.
- CAFR looks at the preceding interval to determine whether to increase or decrease the pacing rate.
- CAFR only works in non-tracking modes, but you can program it ON in DDD mode and CAFR will run during mode switch (DDIR).

Conducted AF Response

Conducted AF Response increases the percentage of biventricular pacing in the presence of AF without raising the mean ventricular rate

Comparison: Conducted AF Response

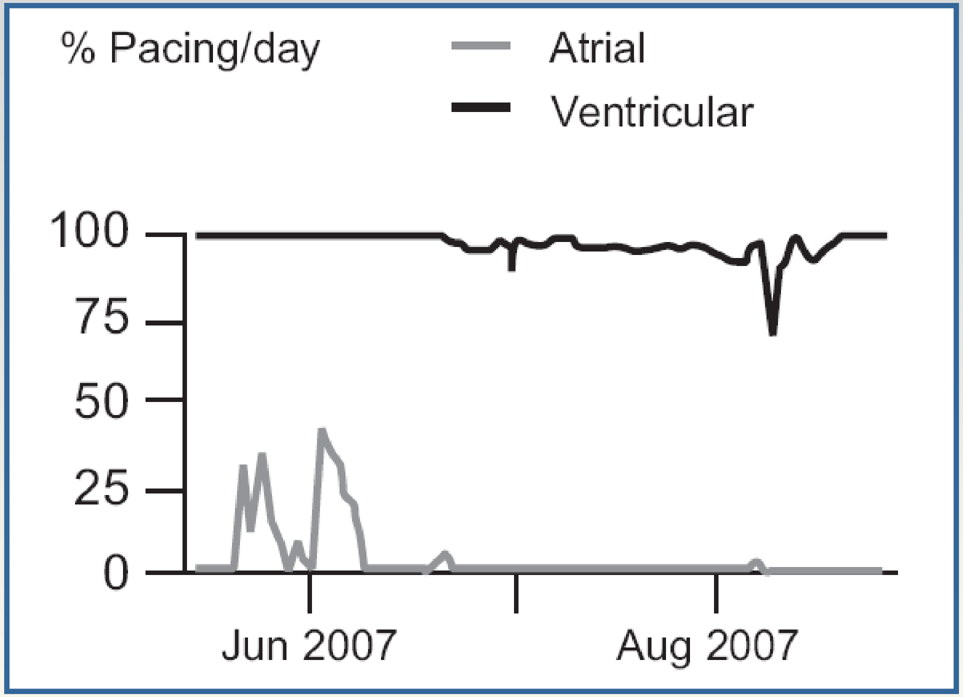


Paroxysmal AF

Persistent AF

Ellenbogen KA, et al. PACE 2003;26:933.
Newman D et al. PACE 2003;26:1036.

Percent Pacing per Day



The % Pacing/day trend displays the daily percentage of atrial and ventricular pacing.

Evaluate this trend for information relative to atrial and ventricular pacing totals.

Consider the following if undesirable pacing percentages are observed

CRT devices
(V-pacing <100%)

- Corroborate with other diagnostic trend finding
- AV optimization
- LV lead dislodgement
- AF with rapid VR
- Evaluating device settings

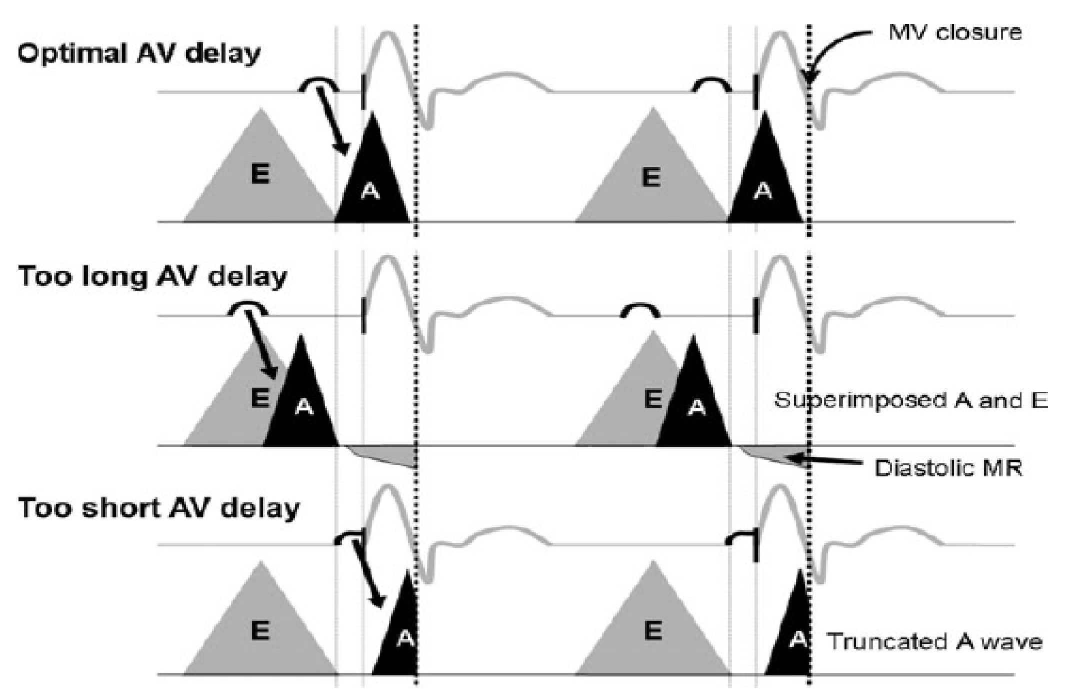
Selecting initial AV delay

- Empiric programming (90-110ms, offset 30-50ms)
- ECG derived determination (20-80% of the PR)
- Echocardiographic optimization

Echo Methods for AV&VV Adjustment

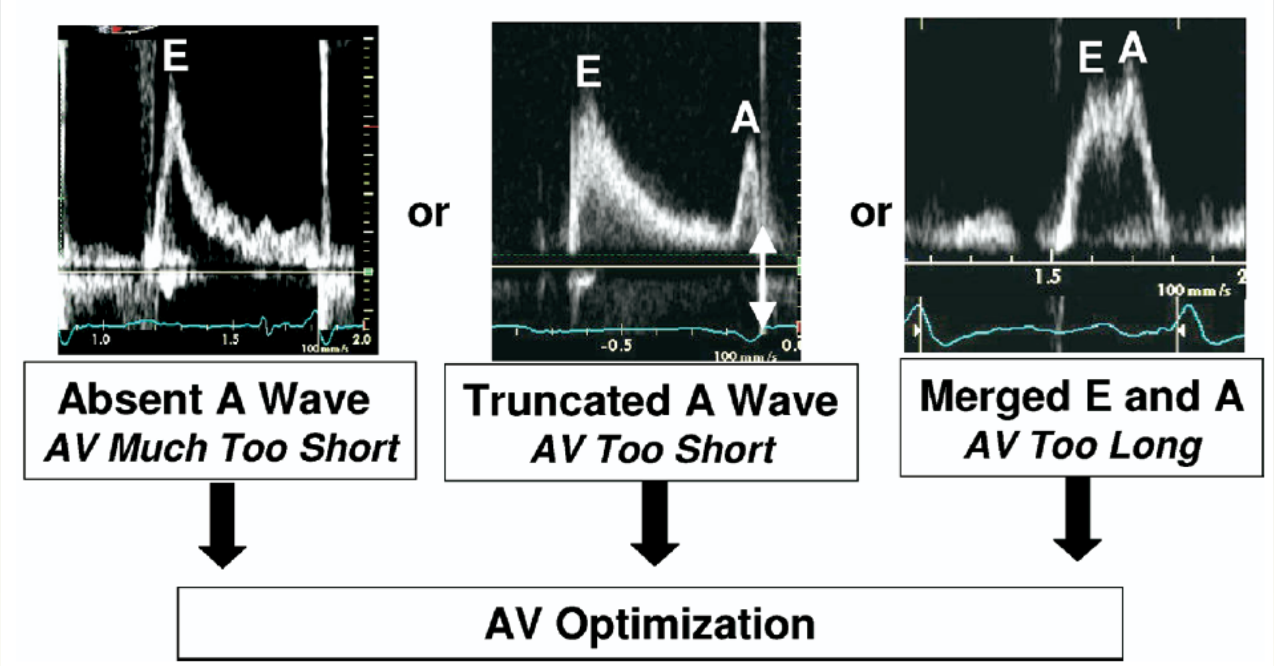
- **AV Adjustment**
  - Iterative method of optimizing transmitral flow pattern*
  - Maximal aortic velocity time integral (aortic VTI)
  - Maximal mitral velocity time integral (mitral VTI)
  - Ritter’s method
- **VV Adjustment**
  - Minimal septal to posterior wall motion delay (SPWMD)*
  - Maximal aortic VTI*
  - Minimal left-ventricular dyssynchrony determined by multi-segmental Tissue Doppler Imaging (TDI)*

Iterative method



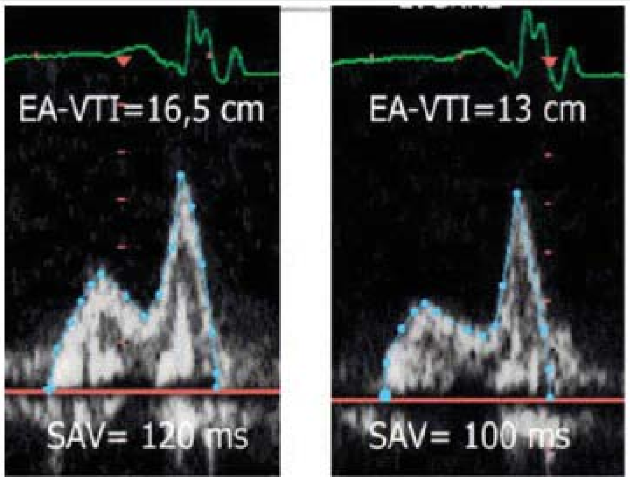
- With an optimal atrioventricular interval, the MV closes at the end of the A wave.
- If the atrioventricular delay is too long (middle panel), the E and A waves become fused and the diastolic filling is shortened. Late diastolic MVReg may then occur.
- If the atrioventricular delay is too short (bottom panel), the E and A waves become widely separated and the A wave is truncated by early MV closure prior to completion of left ventricular filling.

Iterative method

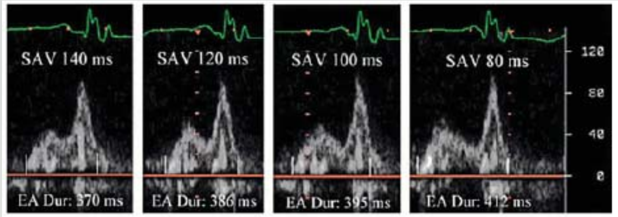


- This method involves programming a long AV delay and then shortening it by 20 ms increments, when monitoring pulse wave Doppler transmitral inflow until truncation of the A wave is noted.
- Optimal AV delay is then identified by lengthening the AV delay in 10-ms increments until A wave truncation is no longer present.

Velocity–time integral methods

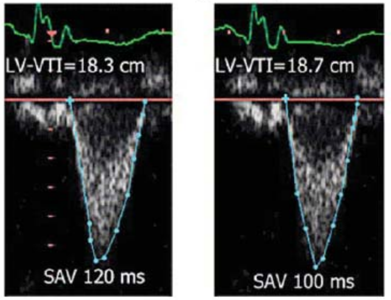


Mitral inflow EA-VTI (r = 0.96)



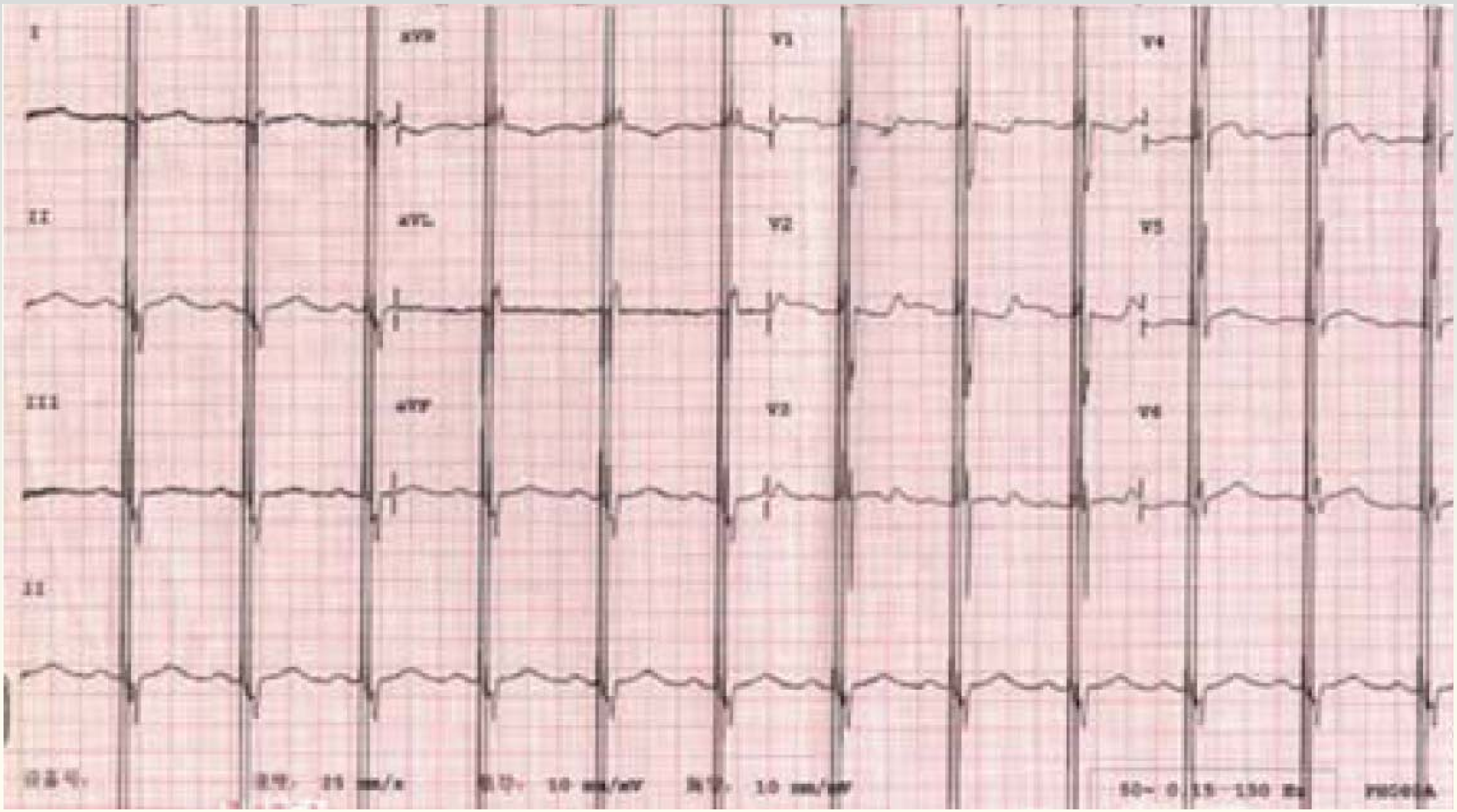
Diastolic filling time
(EA duration) (r = 0.83)

LVOT VTI (r = 0.54)



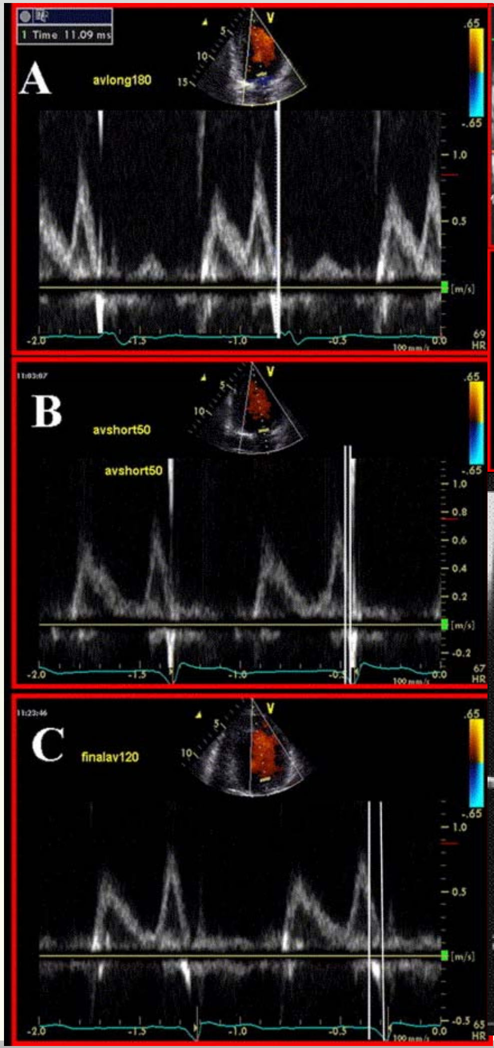
- **AV delay optimization with Doppler echocardiography is often done by assessing the VTI of flow across the LV outflow tract, aortic, or mitral valves.**
- **The optimal AV delay is associated with the largest VTI.**
- **Aortic VTI obtained by continuous wave Doppler is more reproducible than LV outflow tract VTI measured by pulsed wave Doppler.**
- **The mitral VTI is usually obtained from the apical 4-chamber view using pulsed wave Doppler to sample at the tip of the MV leaflets.**

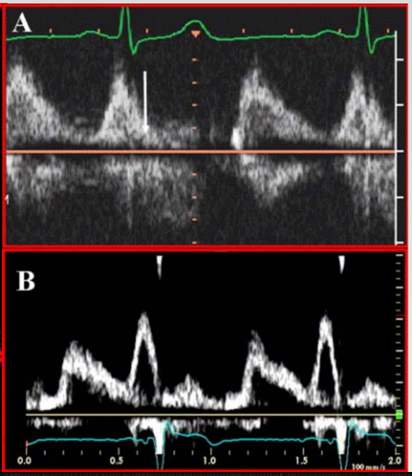
Maintaining AV intrinsic conduction during CRT in non-responders

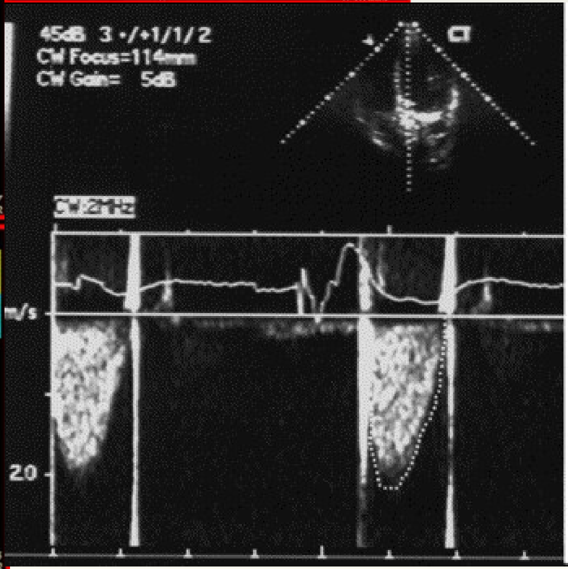


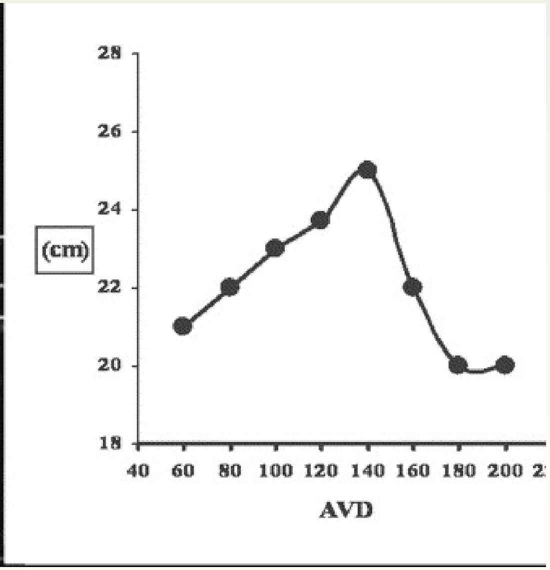
Optimization of AV and VV- delay

1. The AVD is programmed before V-V delay
2. The optimal V-V delay that results in maximal hemodynamic improvement is likely LV before RV pacing and at an average interval of 20 to 40 milliseconds;
3. V-V delays greater than 40 milliseconds are uncommon regardless of the ventricular pacing sequence; and
4. Simultaneous BIV pacing may be the best mode in some patients.
5. Thus, optimal V-V delay programming of CRT devices represents another emerging application of echocardiography.

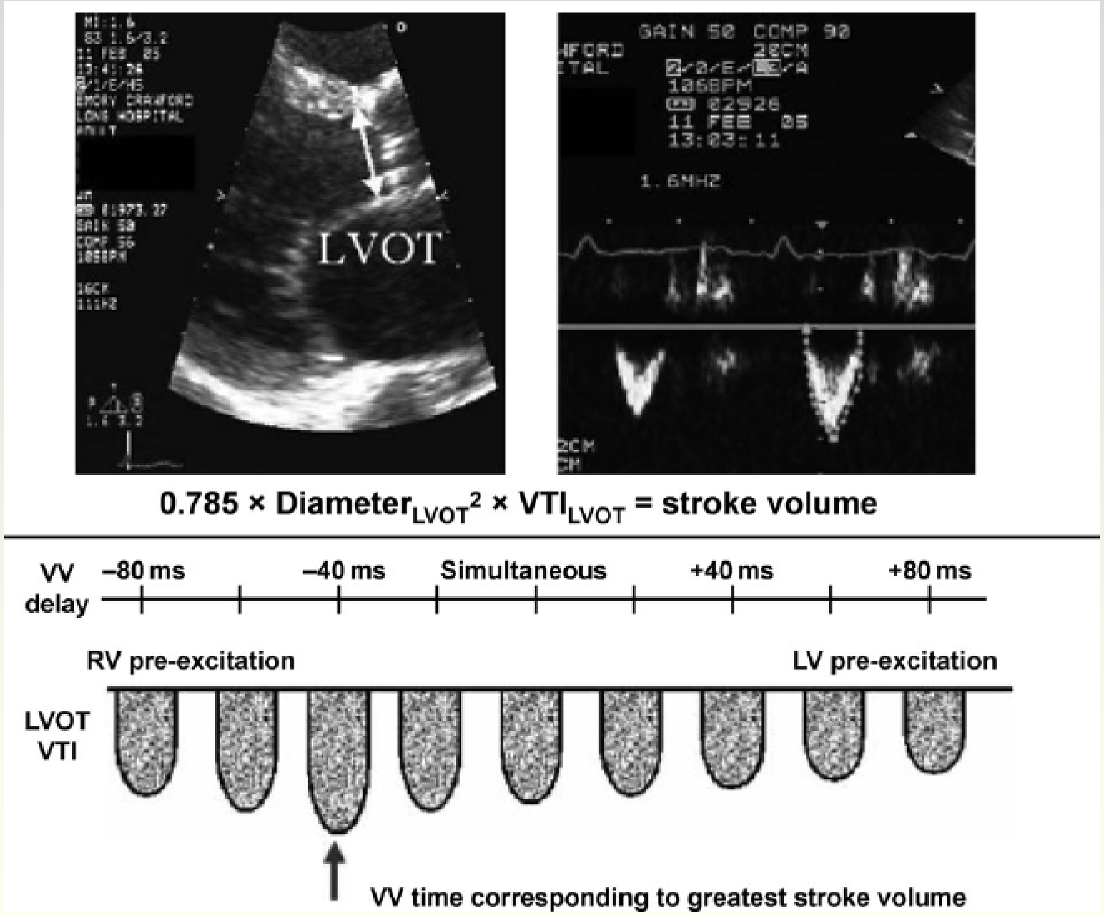








Optimization V-V delay



CRT With Sequential Biventricular Pacing for the Treatment of Moderate-to-Severe HF

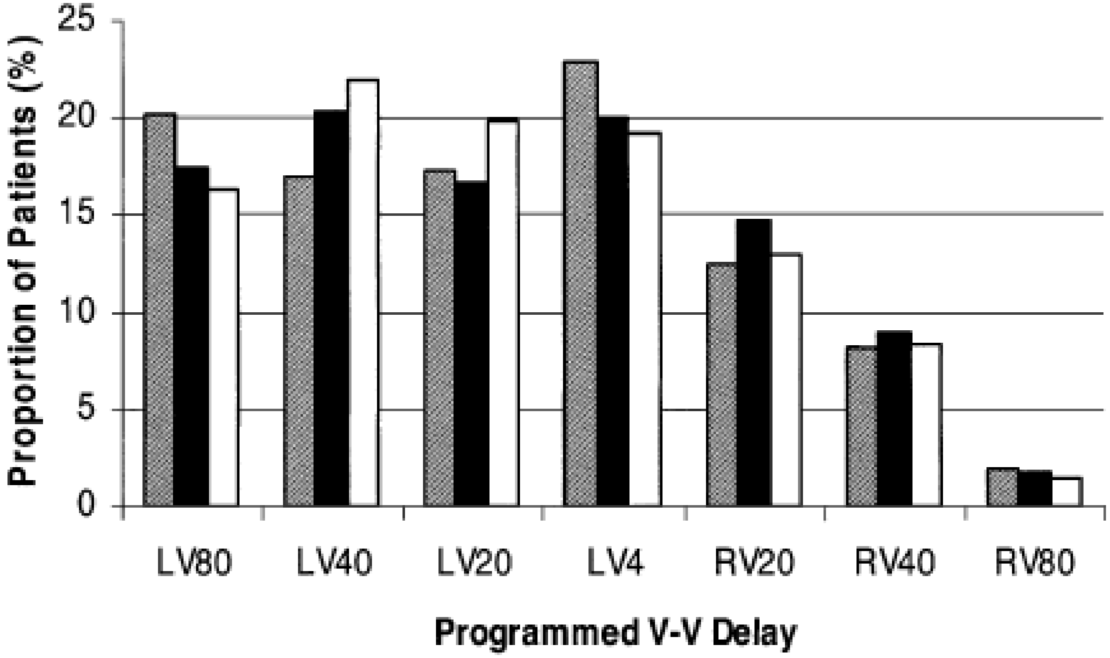


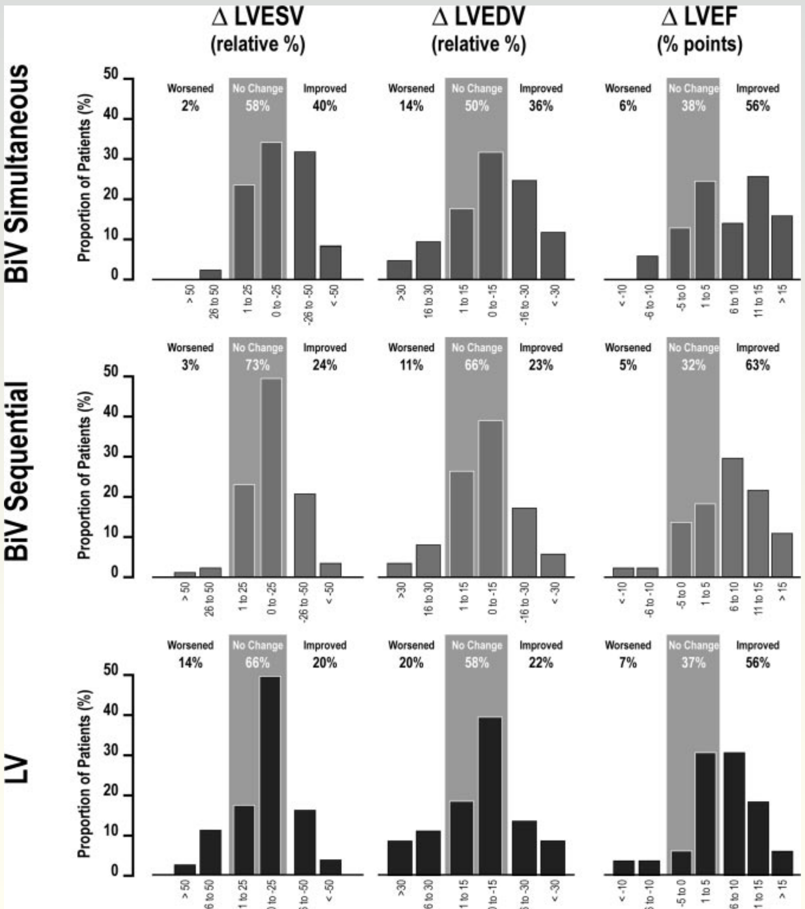
Figure 2. Optimal interventricular timing settings at prehospital discharge, three, and six months. **Diagonally lined bars** = prehospital discharge; **black bars** = three months; **white bars** = six months.

CONCLUSIONS Sequential CRT provided most patients with a modest increase in stroke volume above that achieved during simultaneous CRT. Patients receiving sequential CRT had improved exercise capacity, but no change in functional status or QoL. (J Am Coll Cardiol 2005;46:

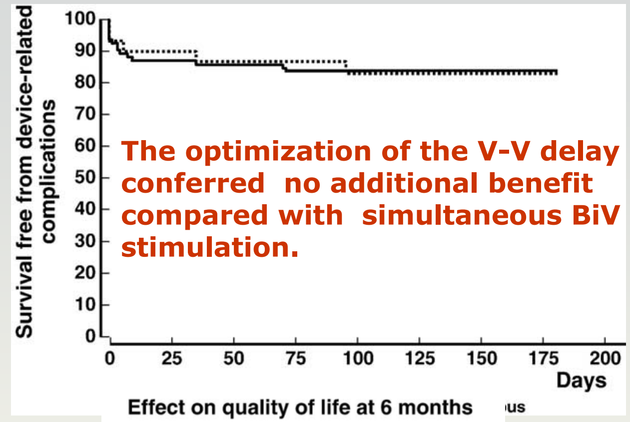
Leon et al, InSync III study

Optimization of VV Interval: Is there any need?

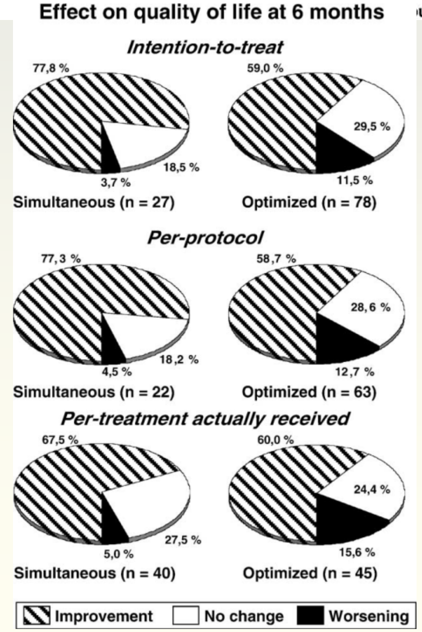
No echocardiographic advantage of sequential BiV pacing compared with simultaneous BiV pacing.



Rao et al Circ 2007



The optimization of the V-V delay conferred no additional benefit compared with simultaneous BiV stimulation.



RHYTHM II ICD
Boriani et al
Am. H. J 2006

Insights From a CRT Optimization Clinic as Part of a Heart Failure Disease Management Program

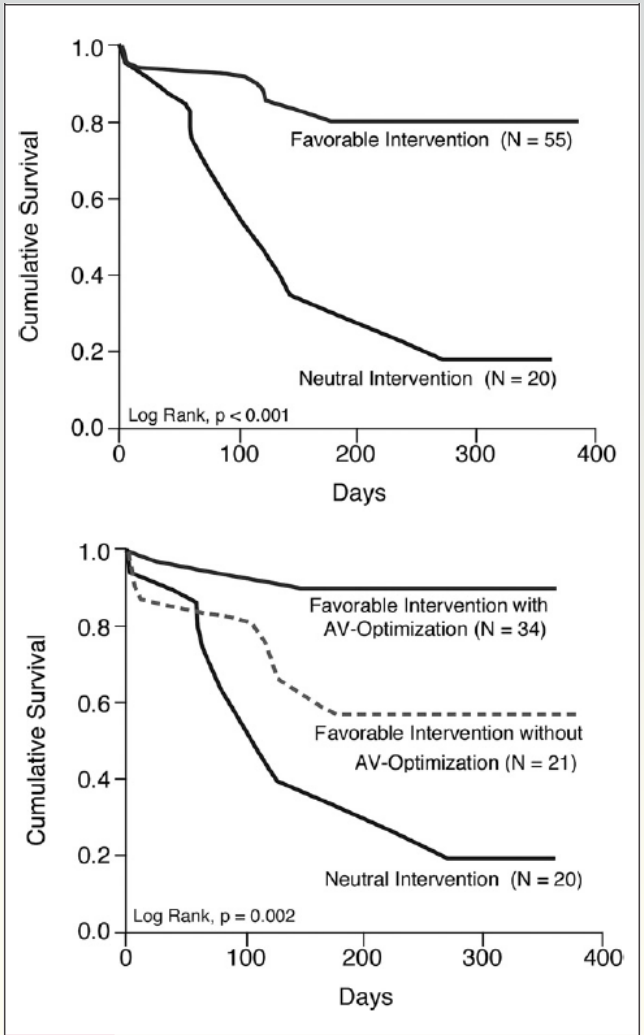
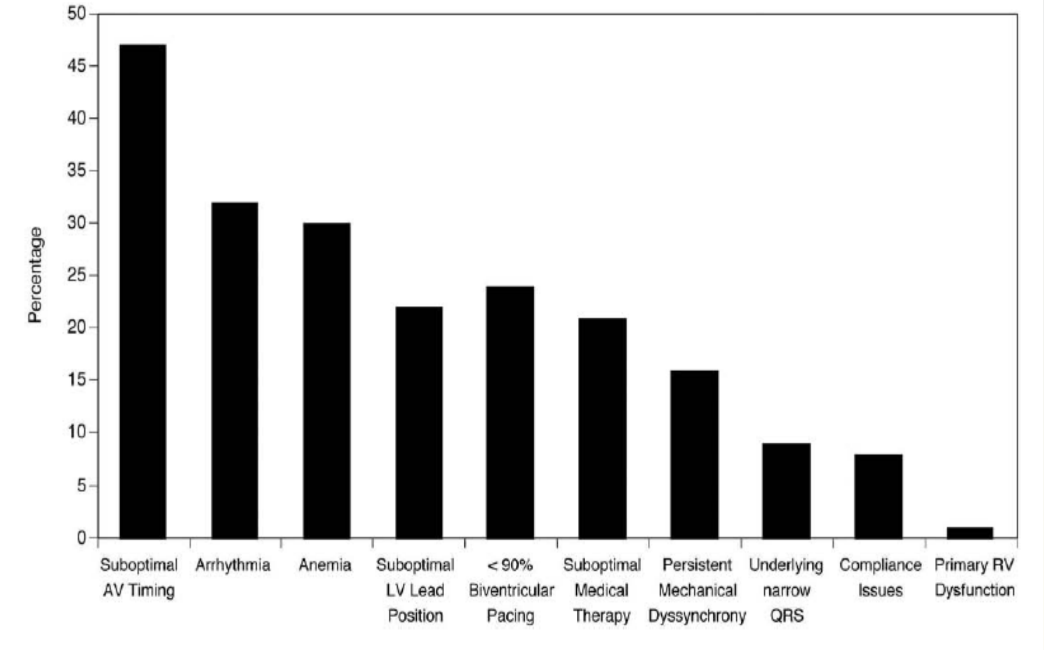


Figure 4 Clinical Outcomes of "Favorable" Versus "Neutral" Interventions With or Without AV Optimization



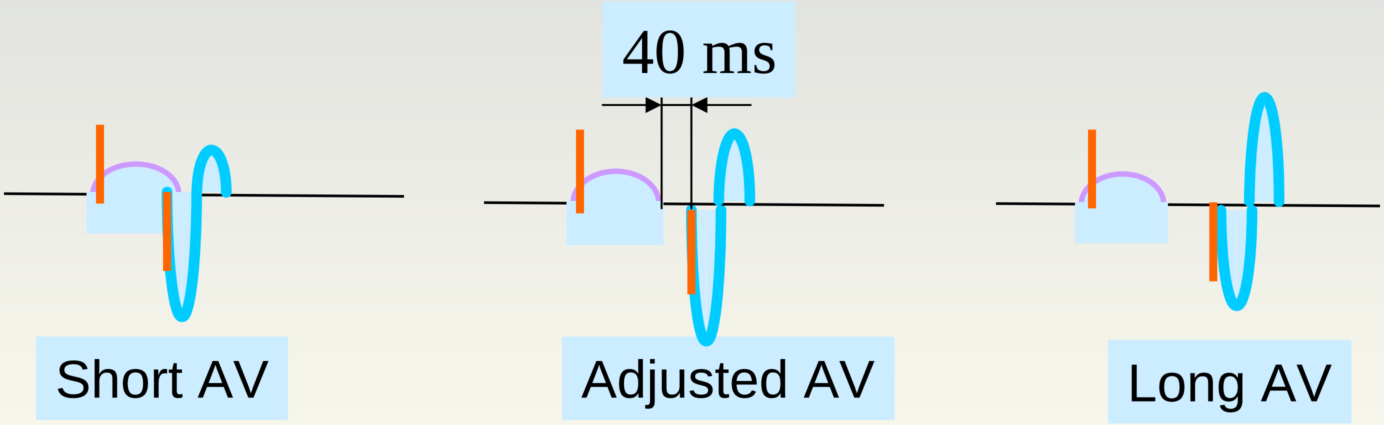
Potential Reasons for Suboptimal Response

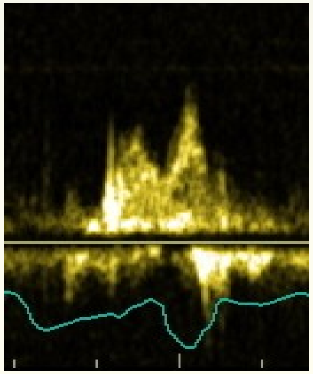
Mullens et al JACC 2009

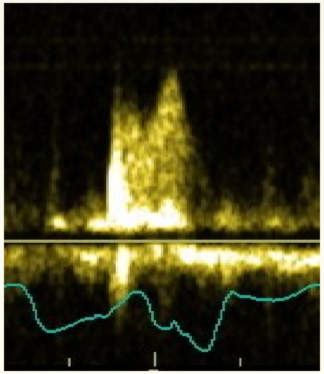
AV Delay Adjustment

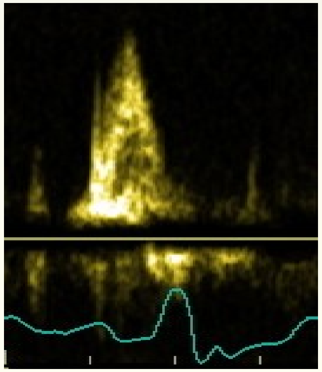
Two steps:

1. **Provide 40 ms (20 ms) between the end of the sensed (paced) P-wave and the start of the paced QRS.**
2. **Ensure BiV capture**





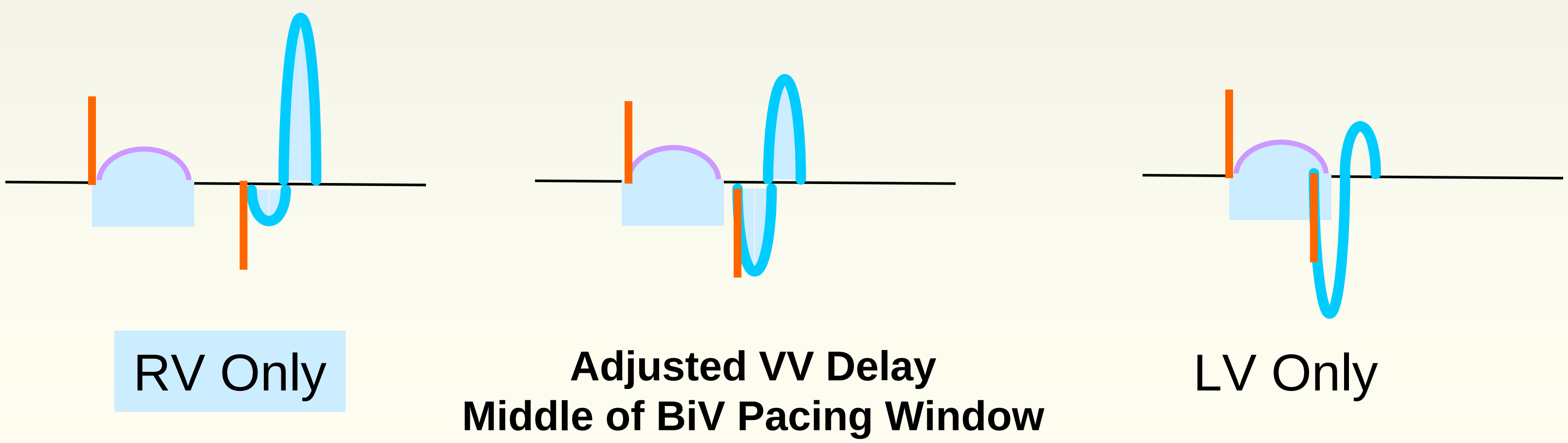




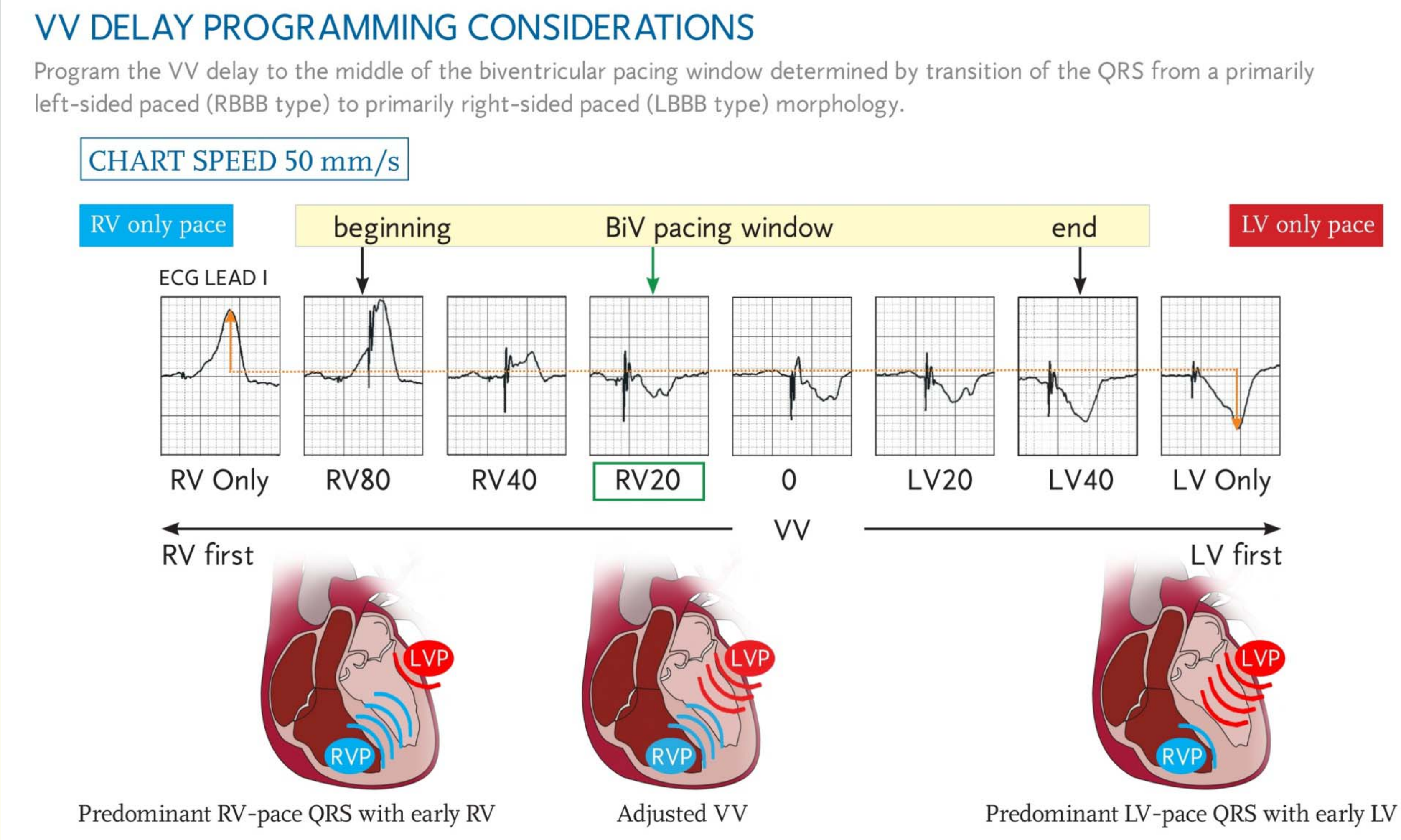
VV Delay Adjustment

Three Steps:

1. **Find the VV setting where the QRS morphology transitions from LBBB (RV only pacing) to BiV pacing. This is the beginning of the *BiV pacing window*.**
2. **Find the VV setting where the QRS morphology transitions from RBBB (LV only pacing) to BiV pacing. This is the end of the *BiV pacing window*.**
3. **Set the VV delay in the middle of the *BiV pacing window*.**



VV Delay Adjustment



Long-term evaluation of the AV Delay

- There is preliminary evidence suggesting that the optimal AV and VV interval changes with time in patients undergoing CRT.

O'Donnell D, et al PACE 2005;28:S24–S26.
Porciani MC, et al Card Fail 2006;12:715–9.
Valzania Cet al Echocardiography2007;24:933–9.
Zhang Q, et al Int J Cardiol 2008;124:211–7.

- Biventricular stimulation will result in LV reverse remodelling with changes in LV ED and ES volumes and pressures over time.
- This dynamic process also includes autonomic changes and may take several months before a new steady state of maximum improvement in LV function is reached.
- The status of AV interval optimization should therefore be assessed periodically.
- Optimization was performed pre-discharge, and after 3, 6, and 9 months in the MIRACLE trial. In CARE-HF, optimization occurred pre-discharge, and after 3, 9, and 18 months. The results of optimization in these clinical trials are not yet reported.
- Further studies are needed to determine how often the AV interval needs to be optimized.

Cardiac Resynchronization System Troubleshooting

- ❑ LV Lead Dislodgement
- ❑ Far-Field P-wave Sensing
- ❑ Fusion Beats
- ❑ Anodal Stimulation
- ❑ Ventricular Sensing Episodes

Device derived features

Monitoring

- Autonomic nervous system (HRV)
- Patient activity
- Haemodynamic status

useful to assess responsiveness or to detect response failure early, before symptoms arise.

Remote monitoring

Remote monitoring

Remote monitoring can be summarized as the continuous collection of patient information and the capability to review this information without the patient present. The collection of this information may require patient participation for measures such as weight, BP, ECG, or symptoms. Newer implanted devices provide access to information such as heart rate, arrhythmia episodes, activity, intracardiac pressure, or thoracic impedance without the need to actively involve the patient.

Continuous analysis of these trends can activate notification mechanisms when clinically relevant changes are detected, and therefore facilitate patient management. Although unproven, remote monitoring may decrease healthcare utilization through fewer hospital admissions for chronic HF, fewer heart failure-related re-admissions, and more efficient device management. Ongoing trials will assess the clinical utility of such an approach.

Class of recommendation IIb, level of evidence C

Long-term follow up

- The long term follow up of the CRT device targets three primary objectives:
  - Ensuring proper device function and continued delivery of CRT,
  - Surveillance for clinically significant events detected by the device that require further evaluation or treatment and
  - Surveillance for complications arising from CRT therapy or the implantation procedure.

Recurrence of symptoms

- A recurrence of symptoms after a period of initial improvement should alert one to the possible loss of resynchronization due to
  - lead malfunction/dislodgement,
  - change in pacing threshold,
  - sub-optimal device programming,
  - development of an arrhythmia interfering with resynchronization.

Follow-up care

Collaboration

- General practitioners
- Cardiologists
- Heart failure specialists
- Electro-physiologists


ΟΚΕΑΝΟΣ